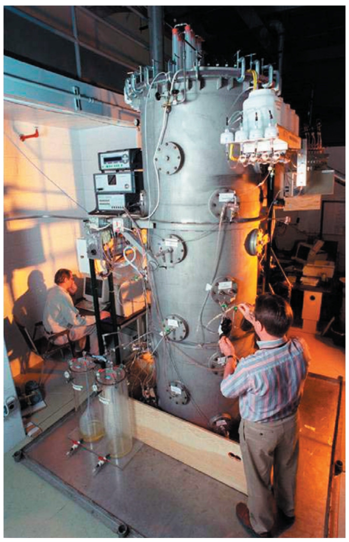
Geochemistry Reseach

Securing the Nation's energy, natural resource, sustainability, and security needs requires significant advancement in understanding the interactions between fluids, natural materials, and contaminated media. INL's Geochemistry Research Group is advancing the scientific basis for addressing society's most critical problems by developing fundamental understanding of coupled processes in complex subsurface environments, and scaling interactive biogeochemical processes from laboratory experiments to field applications.

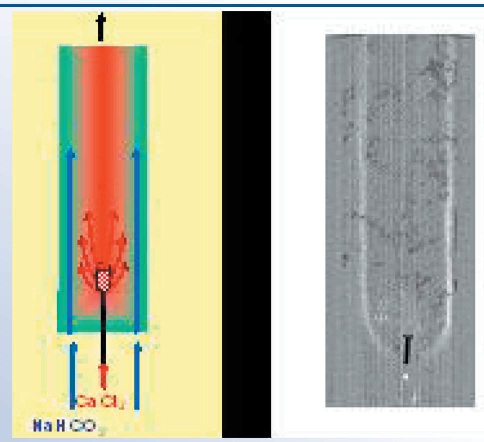


Mesoscale column for measuring vadose zone CO_2 transport.

Areas of research

Fluid flow and mineral precipitation/dissolution

The rate of fluid flow through porous and fractured media depends on the nature of pore space. Pore space can be drastically altered by the formation of precipitates or the dissolution of minerals. Such precipitation reactions are often undesirable because they can clog the aquifer and hinder the delivery of amendments into contaminated aquifers or impede the extraction of potable water or energy from subsurface reservoirs. INL's Geochemistry Group studies coupled flow and mineral precipitation to determine better methods for controlling the precipitation and flow of fluids in the subsurface. Such controls will improve remediation strategies and optimize energy extraction. INL is investigating the potential use of nested dipole well arrays to deliver and mix fluids in the subsurface. The application of biologically mediated hydrolysis of urea is also studied to control the rate and distribution of calcium carbonate precipitation and the co-precipitation of contaminants.



Experiment to create mixing zone where solution is supersatured with calcite (at left); and tomographic image of calcite precipitation at the interface (at right).

Pertubation geochemistry using reactive gases

Perturbation geochemistry is the deliberate and transient manipulation of subsurface chemistry to effect a lasting change on subsurface properties that persists when the system returns to ambient conditions. Introducing liquid solutions to the vadose zone to generate the necessary chemical transitions might mobilize the contaminants deeper into the vadose zone. Further, small-scale preferential flow in the physically and chemically heterogeneous media results in the amendments being inadequately distributed. Another method of perturbing vadose zone geochemistry is to manipulate the composition of soil gas. Diffusion coefficients of gases are orders of magnitude larger than aqueous diffusion coefficients; thus, the amending gases can be rapidly distributed in the subsurface and the scaling of laboratory results to field-scale vadose zone problems is more reasonably attainable. Researchers are determining the efficacy of applying such gaseous amendments to coprecipitate Sr.

Decontamination of building surfaces

The Geochemistry Group has been working with other INL researchers to combine modeling, laboratory, and engineering expertise to develop new approaches for removing up to 99.9% of radioactive fallout from common building material surfaces – many of which are made of geologic materials. Geochemical modeling of laboratory experiments indicates that much of the decontamination process is limited by mass transfer from the bulk material to the surface of the building material. Based on these results, new techniques are being developed to improve and accelerate decontamination of common building materials.

In-situ treatment of arsenic

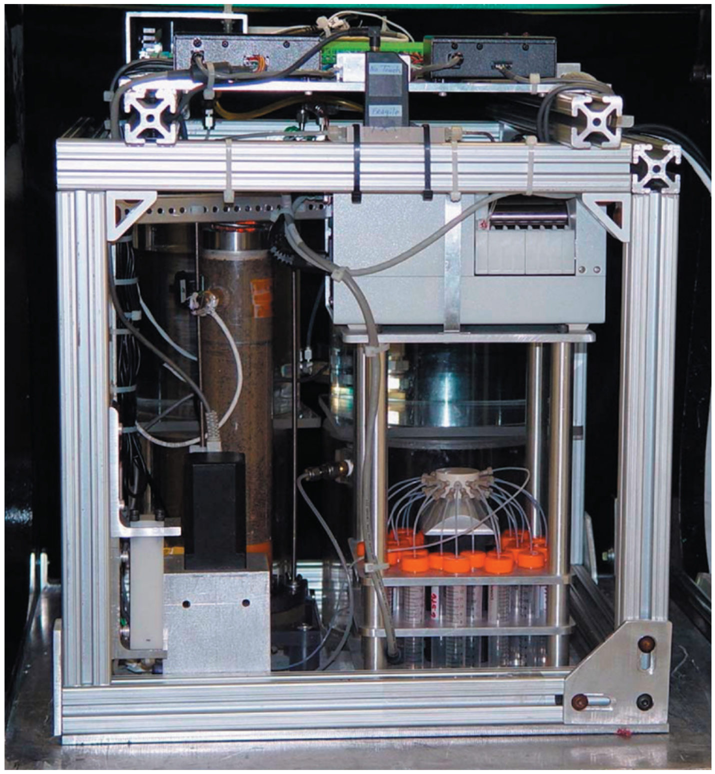
Arsenic is a naturally occurring toxic substance that can appear in drinking water sup-

For more information

Dr. George Redden
Geosciences Research
(208) 526-0765
George.Redden@inl.gov

Dr. Mark Ankeny
Geosciences Manager
(208) 526-5748 Mark.
Ankeny@inl.gov

INL is a U.S. Department of Energy national laboratory operated by Battelle Energy Alliance



Experimental package with column (at left) and fraction collector (at right) used in geocentrifuge vadose zone reactivity experiments.

plies. In response to health concerns from exposure to arsenic in drinking water, the Environmental Protection Agency is lowering the arsenic drinking water standard from 50 μg/L to 10 μg/L. This new standard will impact many water providers in the western U.S., particularly in regions that depend on groundwater. INL's Geochemistry Group is developing cost-effective *in situ* methods to lower arsenic concentrations in water supply wells so wells with more than 10 mg/L arsenic will meet the new standard.

Geochemical reactivity in variably saturated porous media

Experimental package with column (at left) and fraction collector (at right) used in geocentrifuge vadose zone reactivity experiments.

Improved understanding of contaminant migration processes through the vadose zone is required for DOE to provide defensible computational models, better define long-term stewardship requirements, and help design effective barriers to vadose zone contaminant migrations. Conceptual models of contaminant migration in heterogeneous, variably saturated, porous media are improving. One aspect the INL investigates is the dependence of the reactivity in variably saturated porous media being dependent on the moisture content of the medium. A key and novel aspect of the proposed research involves INL's new two-meter geocentrifuge. This experimental approach using a geocentrifuge has distinct advantages over conventional methods. First, data is collected over much shorter time periods than conventional one-gravity techniques, and results in a more complete evaluation of various chemical conditions and materials. Second, controlling acceleration of the sample allows manipulation of the water content and the velocity in the soil columns.

Carbon sequestration

Emerging concern about the connection between global climate change and CO_2 emissions has generated interest in better carbon management – including sequestration in subsurface geological formations. INL in collaboration with Montana State University, the University of Idaho, and Battelle Pacific Northwest Division, has embarked on a multi-year investigation of sequestration in mafic rocks and enhanced coal bed CO_2 sequestration. The program will result in a field pilot demonstration.